MISTI 68.75.02.

SCREW LINE ON A GLOBOID WORM

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ABSTRACT

The parametric function of a vector screw line on a globoid worm is considered. The worm's rotation angles and the worm wheel were selected as parameters. Based on the developed mathematical dependencies, a mathematical model of the screw line on the worm's globoid surface was obtained. The worm in contact with the worm wheel is considered without regard to friction, the choice of parameters is not associated with the coordinate axes, but is tied to the technological parameter on the machine when processing the globoid worm. A single-thread worm is considered. The screw line's pitch is regulated by the gear ratio of the worm gear. An algorithm for calculating points belonging to the screw line on the globoid worm is presented. Finding points belonging to the screw line on the globoid worm allows considering the necessary coordinates on all screw lines of the globoid worm when changing the radius and rotation angles. The work adopted an iterative method for calculating coordinates. The developed model is aimed at obtaining a mathematical model of the globoid worm's screw lateral surface. The scientifically grounded method and algorithm for geometric calculation of gears with a reduced number of rolling elements located on the worm are presented. The developed methodology for calculating the geometric parameters of the end worm gear contributes to the introduction of energy-saving worm reduction gearboxes into production. The results of this work will contribute to a wider introduction of energy-saving gearboxes and multipliers in production, including agricultural mechanization and agricultural engineering.

Keywords: *mathematical model, globoid worm, globoid wheel, screw parametric line, vector function.*

INTRODUCTION

Globoid worms are cut on special machines. In this case, the shaping process consists of the main movement – the rotation of the worm blank and the movement of the cutter feed in a circle. Unlike cutting the Archimedean worm, which is cut on a lathe, the feed relative to the worm axis is not constant, but changes according to the cosine law, the maximum of which is reached when the linear speed vector of the worm wheel rotation is parallel to the axis of the worm being cut. In any case, the screw line is formed on the globoid worm.

MATERIALS AND METHODS

A globoid worm gear's worm, in which the pitch surface is formed by the rotation around the worm axis of a concave segment of the paired worm wheel's pitch circle arc, is considered [1]. Of all the forms [2, 3], a globoid worm is considered, the theoretical surfaces of the turns of which are formed by a straight line. This corresponds to the fact that there is a straight line in the globoid worm's axial section.

On the Archimedean worm, there is a clean screw line [4-7], which is formed on the cylinder, and it is written by the classical function in the parameters of machine tool systems

$$\bar{r} = \begin{bmatrix} R \cdot \mathrm{Cos}\,\phi \\ R \cdot \mathrm{Sin}\,\phi \\ a \cdot \phi \end{bmatrix}, \qquad (1)$$

where R is the radius of the cylinder, φ is the worm's rotation angle around its axis.

The value "a" is a coefficient characterizing the movement along the worm's axis per the rotation angle unit φ, which is equal to the ratio of the linear speed V of movement along the axis to the angular speed w

$$a = \frac{V}{w}. \qquad (2)$$

A point representing the screw line on the globoid worm, in the adopted coordinate system (Fig. 1), has movement in two directions: along the axis OZ and along the axis OY .

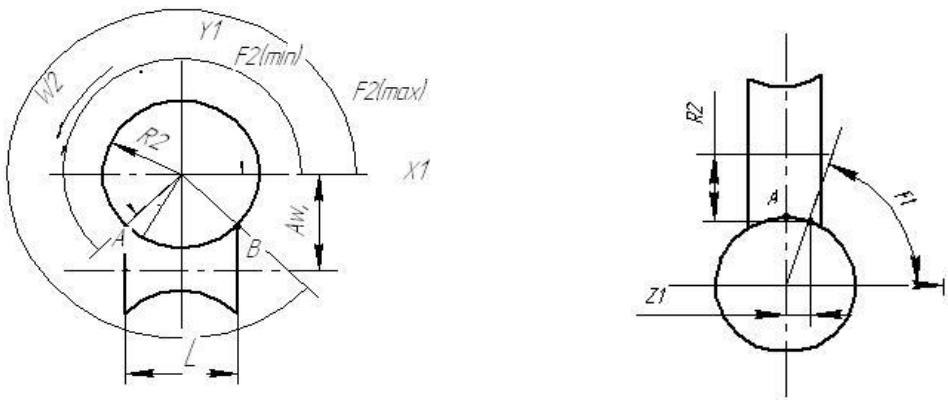

Fig 1. Scheme of globoid worm gear

RESULTS AND DISCUSSION

In the globoid worm at the worm's constant rotation speed w, the linear speed V of movement of the point along the axis is not constant. In addition, its movement reverses the direction.

Any line on the globoid worm's lateral surface represents a screw line on some kind of globoid [8-15]. The set of such lines will represent the description of the globoid worm's lateral surface. The profile of the globoid on the worm depends on the radius of the worm wheel [16, 17].

As variable parameters when calculating the screw line on the globoid worm, the following were selected: the worm's rotation angle F_1 and the worm wheel's rotation angle F_2. The angles are expressed in radians. This allows not to trace the signs of the coordinates in the selected system. They are interconnected by the gear ratio:

$$U = \frac{w_1}{w_2}. \tag{3}$$

Fig. 1 shows a scheme of the globoid worm gear, where R_2 is the radius of the wheel on the radius R_1 of the globoid. When the worm wheel rotates in contact with the worm, their contact occurs between point A and point B. The angle of wrap between points A and B

$$\alpha = arc\,\mathrm{Cos}\,\left(L / 2R_2\right). \tag{4}$$

If fix the radius R_2, then the angle of wrap around the radius of the worm wheel changes from $F_2(\min)$ to $F_2(\max)$ and is expressed in radians.

$$F\,(\min) = \pi + \alpha \tag{5}$$

The variable value of the globoid worm's radius is found by the formula

$$R_1\,(i) = a_w + \mathrm{Sin}\,F_2(i) \cdot R_2 \cdot \mathrm{Sin}\,g\left[l_x(F_2)\right], \tag{6}$$

where a_w is the constant value of the center distance.

The value of movement along the worm's axis is measured from the origin of its own coordinate system at the point O_1 and is calculated:

$$Z(i) = R_1\,(i) \cdot \mathrm{Cos}\,F_1\,(i)\,, \tag{7}$$

$$Y_2\,(i) = R_1(i) \cdot \mathrm{Sin}\,F_1(i)\,. \tag{8}$$

In general, the rotation angle F_1 is related to the angle F_2 by the gear ratio

$$F_1 = F_2 \cdot U\,. \tag{9}$$

Since the planes $O_1X_1Y_1$ and $O_2X_2Y_2$ are aligned and point A is in this plane, then central point of the rotation angle F_1 is in the same plane. Then the coordinate of the point's movement along the axis OX_1 is calculated

$$X_1 = L / 2 + R_2 \cdot \mathrm{Cos}\,F_2\,. \tag{10}$$

When simulating, the change (the angle's increase rate ΔF_2) of the angle $F_2(i)$ depends on the number of iterations n , which is set in an arbitrary way

$$\Delta F_2 = \frac{2\pi - (\pi - 2\alpha)}{n} = \left(\frac{\pi - 2\alpha}{n} \right). \tag{11}$$

The current value of the angle $F_2(i)$ is calculated by the formula

$$F_2(i) = F_2(i) + \Delta F_2 \cdot n . \tag{12}$$

It should be borne in mind that the angle F_1 at point A will be zero.

$$F_1 = 0 \text{ at } F_2(\min) . \tag{13}$$

Then, taking the intermediate value $F_3(i)$ equal $\mathrm{F}_1(i)$, its current value is calculated using the formula

$$F_1(i) = F_3(i) \cdot U . \tag{14}$$

$$F_3(i) = 0 + \Delta F_2 \cdot i \quad \text{that is, at } i = 0 . \tag{15}$$

And coordinates Z_1 and Y_1

$$Z_i = R_1 \cdot \mathrm{Cos}\, F_1 , \tag{16}$$

$$Y_i = R_1 \cdot \mathrm{Sin}\, F_1 . \tag{17}$$

Let's accept i in the range from $i = 0$ to $i = n$ (whole numbers).

Fig. 2 shows a block diagram of an algorithm for calculating the profile of the globoid worm; a description of an algorithm for calculating the coordinates of points of the screw line on the globoid worm.

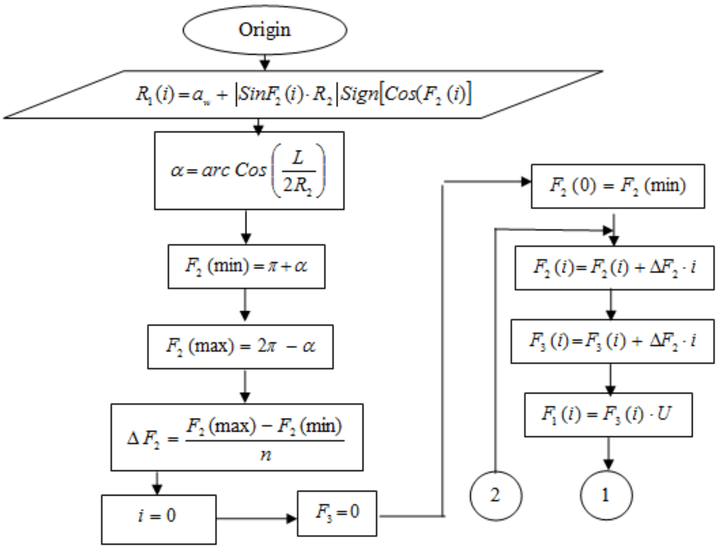

Fig. 2. Block diagram of algorithm for calculating the profile of the globoid worm

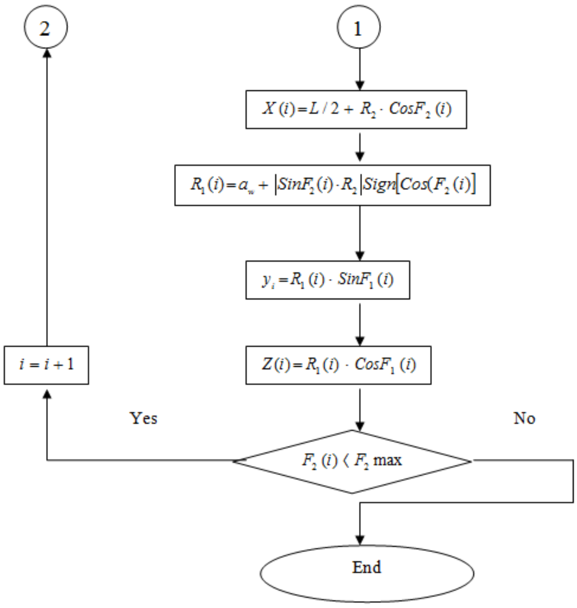

Fig. 2 (continuation). Block diagram of algorithm for calculating the profile of the globoid worm

CONCLUSION

Thus, based on the above, the coordinates of the screw line points on the globoid are calculated. The set of screw lines allows simulating the globoid worm's screw surface

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